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WIRELESS POWER TRANSMISSION BY INDUCTIVE COUPLING

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ABSTRACT

Wireless Power transmission is the transfer of electrical power from a power source to an electrical load without using discrete manmade conductors. The reason for going to wireless power transfer system is to provide reliable power transmission at low cost and to make life more comfortable. This wireless power transmission system is completely eco-friendly and efficient. Just imagine the future with wireless power where in there will be no need of power cables and no need to plug in the electrical devices to the electric sockets for charging which brings a profound change in the society. The core technology used in the wireless power transmission system is Inductive coupling through magnetic fields. An Impedance compensating circuit is also used to achieve maximum power transfer. The core technology is similar to those found in transformers, except primary and secondary windings are physically separated and tuned to resonate for increasing their magnetic coupling. These magnetic field generated by the primary coil is arranged to interact vigorously with matched secondary windings where the load is connected.

KEYWORDS: Inductive Coupling, Residual Magnetic Field, Resonance, Tesla Theory, Wireless Power Transmission.

INTRODUCTION:

In recent days, global scenario has been changed a lot and there is tremendous development in every field particularly in electrical field. If we don't converge our innovative ideas for the development of new power technologies we may face a decreasing trend in the development of power sector. The transmission of power without wires may be one excellent alternative for electricity transmission. This remarkable discovery of wireless power and its core technologies even in present day system are based on Dr. Nikola Tesla's contribution in the field of all wireless systems. This shows us that he is indeed the "Father of Wireless systems". The most famous Wardenclyffe tower in Colorado Springs (Tesla tower) also called as "Magnifying wireless transmitter" was designed and constructed by Dr. Nikola Tesla which used Ionosphere to transmit the electrical power all over the earth. The Colorado Springs was commonly known for its Geo-Magnetic activates where Dr. Nikola Tesla built his laboratory, in the center of the lab he built a massive transformer with primary of the transformer was grounded and other end was raised at a great height. This transformer produced a voltage of several million volts at a frequency of 150 thousand hertz which created a manmade lightning which was 40m long. The tower frame was 57m long with a steel shaft that dipped into the ground and a huge copper hemisphere which worked as a powerful amplification transmitter was installed at the top of the huge tower. With this Dr. Nikola Tesla was able to lit 200 electric bulbs in a radius of 25 miles from the tower. The core technology he used was "The currents transmitted by high frequency standing wave energy". With this technology, the power would be transmitted across large distances with negligible losses. But this was an unfortunate incidence that people of the century was not in a position to recognize his splendid work. He is well known as "scientist ahead of time". Otherwise we may have transmitted electricity wirelessly and would have converted our mother earth a wonderful adobe full of Electricity. The figure 1 shows tesla tower and figure 2 shows the image of Nickola Tesla.

Figure 1

Figure 2

Types of Wireless Power Transfer System

- Inductive Coupling - Short Range
- Resonant Inductive Coupling - Medium Range
- Capacitive coupling - Short range
- Resonant Capacitive Coupling - Medium Range
- Microwave Power Transmission - Large Range

The Frequency required and the efficiency of inductive and Capacitive coupling is given in the below table;

Technology	Efficiency	Range	Frequency
Inductive Power Transfer	Medium	Medium	10-50 KHz
Capacitive Power Transfer	Low	Medium	100-500 KHz

Now let's see the possible ways of utilizing these categories of wireless Power Transmission;

1. **Inductive Coupling:** It consists of two coils one is transmitter coil and the other one is receiver coil. An alternating current in the transmitter coil generates a magnetic field which induces a voltage in the receiver coil. It is the simplest method of wireless power transfer. This method is same as the one used in transformers, In transformer core acts as a path for the flux but in Wireless Power transmission there is no core, Air cored coils are used. The power can be transmitted only up to few meters. The efficiency of the power transfer depends on the coupling between the inductors and their quality.

2. **Resonant inductive Coupling:** It consists of a capacitor and an inductor to form the resonator. The capacitor act as an electric field and inductor act as a Magnetic field. Capacitor is connected in parallel the coil. Resonance makes two objects interact very strongly. The power transmission is possible only when the resonance condition satisfied. Resonance is the phenomenon in which the reactance of the capacitance (XC) and the inductance (XL) should be equal.

3. **Microwave Power Transmission:** This is the long-range power transmission. The power can be transmitted to a long distance up to kilometers. There are three steps involved in this method. First one is electrical energy is converted to microwave energy. Then the microwave is captured using Antenna. Then the microwave is converted into electrical energy. AC cannot be directly converted to microwave energy. AC is converted to DC. Then the DC is converted to microwave using magnetron.

WORKING PRINCIPLE:

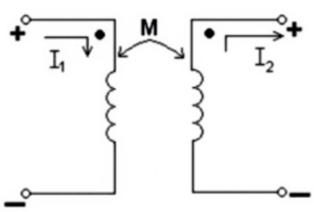

Figure 3

Wireless electricity works on the principle of "Mutual Inductance" between two coils. The transmitter coil is connected to the AC supply and the receiver coil is connected to the load. When the power is switched on the transmitter coil con-

verts electricity into magnetic field which is oscillating at resonant frequency. Then the receiver coil at the receiving end convert magnetic field into electricity. The power can be transferred from transmitter coil to receiver coil based on faraday's laws of electromagnetic induction. The current entering at one end and leaving at another end of coil is determined by dot convention. The number of turns in the primary and secondary winding may be equal. Figure 3 shows the mutual coupling and dot convention between the coils where M is the coupling factor.

Block Diagram of Wireless Power Transmission:

The Wireless Power Transmission system consists of a power source which is a high-speed switching circuit for generating high frequency signals, primary impedance compensating network and primary magnetically coupled coil; all these components put together to form transmitter circuit. And receiver circuit comprises of secondary magnetically coupled coil, a secondary impedance compensating network, a high frequent rectifier, a voltage regulator and a DC load.

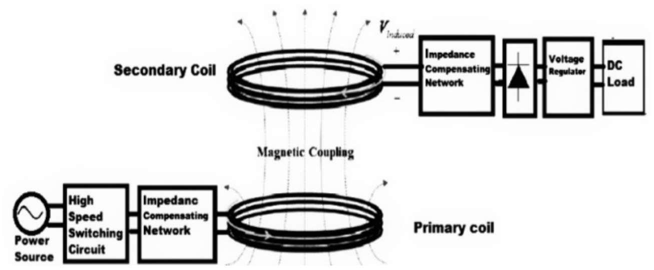

Figure 4

Figure 4 shows the block diagram of wireless power transmission. The high-speed switching circuit is a high frequency resonant inverter that comprises of power MOSFETs and gate triggering circuits. A power MOSFET is a Metal Oxide Semiconductor Field Effect Transistor (MOSFET) designed to handle significant power levels and can operate at high frequencies in the range of hundreds of kilo Hertz. With the advancement in the field of power electronics a new power MOSFET (SiC MOSFET) that can operate at frequencies up to Mega Hertz which is used for high frequency switching applications. The impedance matching network has a significant role in Wireless Power Transmission system.

The impedance matching network reduces the VA (volt-ampere) rating of the power source by minimizing the reactance of input impedance and increase the power transmission efficiency by utilizing the magnetic field resonance.

The time varying magnetic field is generated from the primary coil and is transmitted to the secondary coil. A high frequency rectifier is used to convert high frequency AC power into a DC power. There are two losses associated with the diodes in a high frequency rectifier; losses due to the forward conduction of the diodes and the high frequency loss according to the switching time of the diodes. These losses act as the reverse recovery time for the diodes. To eliminate these losses, Schottky diodes or ultrafast diodes are used in the rectifier circuit instead of normal 1N4007 diodes. The voltage regulator is used to stabilize and control the DC voltage level according to the required load voltage.

EXPERIMENTAL WORK:

Figure 5

Figure 6

The figures 5 & 6 shows the hardware model of Inductive coupling. In our project, Wireless Power Transmission is done by using inductive coupling technique. In this we have converted AC voltage to DC voltage using rectifier. The power is transmitted from transmitter to receiver as DC voltage due to mutual induction principle. The simple working proto-type of a wireless power transmission system require some copper wires for making primary and secondary coils which may be of same turns, a BD139 Transistor which acts as a static switch and a capacitor is connected at the receiving coil. The basic theory behind this include the inductive energy that is transmitted from a transmitter coil to the receiver coil through magnetic field. The transmitter coil is connected to a power source through a high-speed switching circuit. The magnetic field links with the secondary coil and induces an EMF on the principle of Faraday's laws of Electro-Magnetic induction. In the receiving coil, a capacitor may be connected for maintaining the output constant.

NEW INNOVATIVE IDEAS FOR WIRELESS ELECTRICITY:

Wireless power transmission is a developing technology for which many innovative ideas must be converged for its ideal use. Here are some of the ideas that can bring profound change in the existing technologies.

RESIDUAL MAGNETIC FIELD:

In transformers, the magnetic flux generated in the primary winding passes through the transformer core and reaches the secondary winding. The transformer core acts as a guided path for the magnetic flux. Keeping this in mind for wireless power transmission, we need to get a guided way for the primary flux to link with the secondary flux which also reduces the leakage of primary flux for achieving this we need to have a magnetic field induced initially in the secondary winding which attracts the flux generated in the primary winding without letting the primary flux get out of its way.

The Magnetic field induced initially in the secondary winding is called as induced magnetic field or residual magnetic field. The efficiency and the range of power transmission is considerably increased.

APPLICATIONS OF WIRELESS POWER TECHNOLOGIES:

Wireless power transmission is used to power electrical devices in case where the interconnecting wires are inconvenient or hazardous. Wireless electricity can eliminate frequent plugging in of devices to the electrical sockets and provide an efficient way to transmit the power to the moving parts where electricity can't be reached through wires. Wireless Electricity finds its application where ever we use electrical loads like mobile phones, laptops, electric vehicles and all other domestic electrical utilities. It can also bring more and more electrical Vehicles on road by putting them under wireless electricity. This Technology can provide a convenient safe and flexible means to charge electric appliances.

WIRELESS POWER TRANSFER IN ELECTRIC VEHICLES may bring a profound change in the charging system. Plug in Electric vehicles need cables & Plug charges but physical plug charges and Cables may become hassle and messy. With the system where we have to physically plug in chargers, there are number of occasions where the owners can often forget to charge the vehicles. Figure7 shows the wireless charging in Electric vehicles.

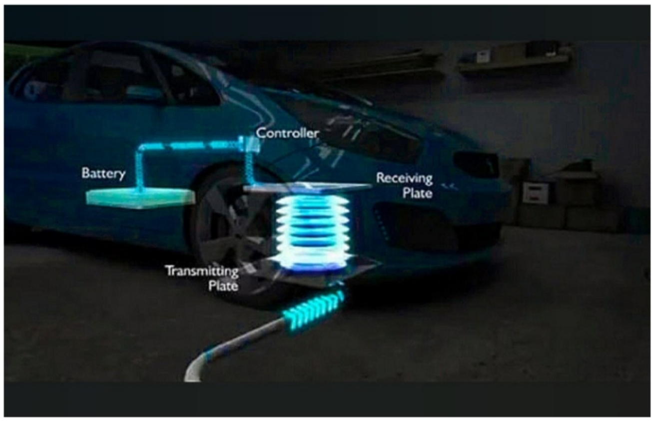

Figure 7

For stationary applications like charging of plug in electric vehicles at home, Wireless transmission technology adds a convenient factor compared to actual plugging in. which means the vehicle will have full charge every morning. By reconfiguring the transformer and altering the resonant frequency energy is transferred to the battery with lower energy losses. Sufficient power for the battery can be transferred from the primary to secondary circuit without significant energy losses. The electrical power is then transmitted to the battery which is electrically coupled to the secondary circuit through the air core transformer.

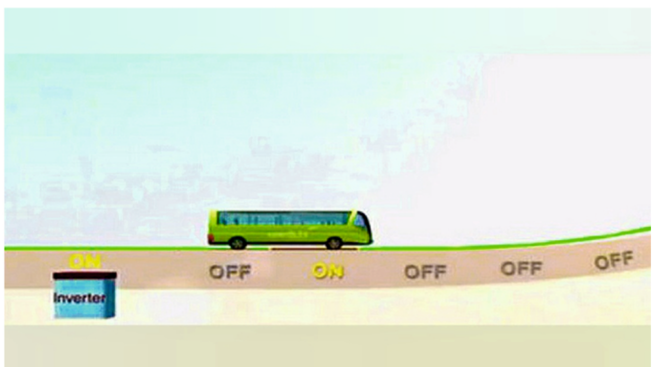

Figure 8

Figure 8 shows dynamic charging with segment control technology. Dynamic charging in simple words mean charging of the electrical vehicles even under the movement in electrically equipped roads. In larger cities, dynamic charging offers an even greater impact utilizing existing infrastructures as vehicles travel along the busy freeways wireless charging can also occur while the vehicle is in motion. The transmitting plate kept under the road will be ON only when the vehicle passes over the plate (the vehicles having receiving plate comes into area of transmitting plate it turns on) this is known as segment control technology. The power lines are managed by Segment Control Technology, which supply power to the vehicle only when it is passing over the power line. This technology prevents a magnetic field from being generated while pedestrians walk or other vehicles run on the road as well as wasting of energy. Dynamic charging allows electricity to supply a very large fraction of the energy for the transportation sector and reduce considerable petroleum consumption. Previously traffic delays now provide of charge while passing over in motion charges. Rain does not affect the charging capability and the transmitting circuit.

ECONOMIC IMPACT

The concept looks to be costly and complex initially. The investment Cost of Tesla Tower was $150,000 (1905). In terms of economic theory, many countries will benefit from this service. Today we are spending more money to installation of poles, wires and cables. In wire mode power transmission maintenance is frequently required. It will increase the total cost for power transmission and fault level is more due to wire coloration. But in the concept of wireless power transmission provide minimal maintenance cost.

CONCLUSION

The transmission of power without wires is not only a theory, it is now a reality and in future it should be made available for domestic electrical loads. It provides non-radiative energy transfer and it does not harm the environment and human beings. The experimental studies have observed the power transmission is efficient up to 20cm distance. The electrical energy can be economically transmitted without wires to any terrestrial distance if the coupling coefficient between the coils are good this technology just acts as a transformer and gives an efficiency in the range of 90%. This can be transmitted to anywhere in the globe and eliminate the need for an inefficient, costly, and capital-intensive grid of cables, towers, and substations. In near future, the world should be completely wireless.

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